

Strategic Plan for the U.S. Geological Survey Status and Trends of Biological Resources Program: 2004–2009



Circular 1277

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In Memoriam

In memory of Timothy M. Bartish (1956–2004), who, as leader of the Biomonitoring of Environmental Status and Trends (BEST) Program, made significant contributions to ecological monitoring on a national scale, to the development of this Plan, and most importantly, to the lives of his family and many colleagues and friends.

Strategic Plan for the U.S. Geological Survey Status and Trends of Biological Resources Program: 2004–2009

By Paul V. Dresler, Daniel L. James, Paul H. Geissler, Timothy M. Bartish,
and James Coyle

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Foreword

The Status and Trends of Biological Resources Program of the U.S. Geological Survey (USGS), Biological Resources Discipline (BRD), established a Program Planning Committee to develop a 5-year Strategic Plan. The Committee was selected from nominees recommended by USGS-BRD Science Center Directors and included representatives from the Water Resources, Geology, and Geography Disciplines. Committee members represent a wide range of regional, interdisciplinary, and intra-bureau scientific and technical perspectives.

The Committee was encouraged to solicit input from peers within and outside of the USGS, including other Department of the Interior (DOI) bureaus, other federal and state agencies, and non-governmental organizations. This dialog with internal and external clients and partners ensured a lively debate concerning the challenges of and approaches to meeting Program goals. Committee members were also tasked with summarizing the goals, objectives, deliverables, and measures of success for selected ongoing Program activities. The resulting "topical papers" provided the basis for discussions that led to the Program priorities addressed in this Strategic Plan.

The Plan describes a vision for assessing the status and trends of the Nation's biological resources and sets milestones for measuring progress over the next 5 years. It presents a strategy for moving the Program beyond a "large collection of projects" (USGS, 1999) toward an integrated and focused effort to address identified monitoring information needs. A critical aspect of this Plan is the development of a National Monitoring Framework for biological resources. The Framework is intended to provide a structure for achieving better data sharing and integration related to biological monitoring.

This Plan also envisions long-term participation and involvement by the full community, public and private, that may collect and/or use biological resource monitoring data and information. It addresses requirements of the Office of Management and Budget (OMB) Program Assessment Rating Tool (PART), and meets the planning process requirements outlined by the USGS Director. Just as important, the Plan provides for accountability of the Program to the USGS, DOI, OMB, Congress, and the public.

Recognizing that input from stakeholders is critical to Plan success, the Program solicited review and comment on the Plan from individuals representing a variety of federal, state, tribal, and non-governmental organizations. Their thoughts and comments were integral to creating a plan relevant to resource management needs.

Acknowledgments

The efforts, dedication, and input of our many colleagues in the USGS and partner/client agencies and organizations clarified our vision and refined and enriched the Status and Trends of Biological Resources Program Strategic Plan. To begin with, we would not have a Plan were it not for the initial labors, expertise, and vision of the Planning Committee. The team comprised:

Steve Amstrup, Alaska Science Center
 Tim Bartish, Status and Trends of Biological Resources Program, BEST Program
 Jayne Belnap, Southwest Biological Science Center
 Rob Bennetts, Florida Integrated Science Center
 David Busch, Forest and Rangeland Ecosystem Science Center
 Steve Corn, Northern Rocky Mountain Science Center
 Paul Dresler, Status and Trends of Biological Resources Program Coordinator
 George Durner, Alaska Science Center

Paul Geissler, Status and Trends of Biological Resources Program, National
 Park Monitoring
 Tom Gunther, Geographic Information Office
 Pam Haverland, Columbia Environmental Research Center
 Marshall Howe, Patuxent Wildlife Research Center
 Dan James, Status and Trends of Biological Resources Program
 Barry Johnson, Upper Midwest Environmental Sciences Center
 Doug Johnson, Northern Prairie Wildlife Research Center
 Jimmy Johnston, National Wetlands Research Center
 Tim King, Leetown Science Center
 Lee Lamb, Fort Collins Science Center
 Tom Loveland, Geography Discipline, EROS Data Center
 Steve Moulton, Water Resources Discipline, National Water Quality Assessment
 Karen Oakley, Alaska Science Center
 Dave Pyke, Forest and Rangeland Ecosystem Science Center
 Mike Ruggiero, Biological Information Management Program, Taxonomic Information
 John Sauer, Patuxent Wildlife Research Center
 Chris Schmitt, Columbia Environmental Research Center
 Steve Schwarzbach, Western Ecological Research Center
 Bern Shanks, Western Regional Office
 Tom Stohlgren, Fort Collins Science Center
 David Woodson, Western Regional Office
 Lisa Zolly, Biological Information Management Program

Our cadre of reviewers provided invaluable suggestions and insights to make the Plan more reflective of land and resource manager needs. We especially thank the reviewers from the U.S. Department of Agriculture Forest Service, Bureau of Land Management, and U.S. Fish and Wildlife Service, as well as The Ornithological Council, International Association of Fish and Wildlife Agencies, and many of our colleagues at USGS Science Centers across the country for their significant contributions to the quality of this Plan.

Special thanks go to Carolyn Bell, USGS Communications Officer, who served as facilitator for the Planning Committee meetings, and to Tony Frank, USGS Eastern Regional Office, and Mike Ruggiero, who persevered in advancing the draft Plan through its later stages.

Finally, we acknowledge Melissa Dresler, who reviewed and edited the many iterations; Juliette Wilson of Johnson Controls World Services (under contract to the USGS Fort Collins Science Center), who incorporated review comments and conducted the final edits; and Jennifer Shoemaker and Dora Medellin at the Fort Collins Science Center, who designed and generated the final publication.

Executive Summary

The mission of the USGS Status and Trends of Biological Resources Program is to measure, predict, assess, and report the status and trends of the Nation's biological resources to facilitate research, enable resource management and stewardship, and promote public understanding and appreciation of our living resources. Determining the status (abundance, distribution, productivity, and health) and trends (how these variables change over time) of our living natural resources is critical for their protection or restoration. The Program provides the USGS, other agencies of the Department of the Interior (DOI), other federal and state agencies, and the public with science-based monitoring data and information for local, regional, and national assessment of biological resources and the ecosystems that support them.

The Status and Trends Program developed this Strategic Plan to better meet the biological inventory and monitoring information needs of the land and resource management community. By setting clear goals, strategies, and measures of success, this Plan will guide development of a more cohesive, unified Program over the next 5 years. Further, the Plan outlines strategies for increasing communication, cooperation, and collaboration among the USGS and other agencies and organizations involved in biological resource monitoring. Most importantly, the Plan envisions a process where scientifically valid biological status and trends information, across multiple spatial and temporal scales, is readily available to land and resource managers and their stakeholders to inform and enable sound stewardship of the Nation's biological resources and their supporting ecosystems.

Over the next 5 years, progress made in addressing each long-term Program goal and its associated 5-year priority objectives will gauge the Plan's success. Specific strategies, outcomes, and measures of success related to accomplishing these goals and objectives, both programmatically and within the context of specific taxa, are described in this Plan and are summarized in Tables 1 and 2 and Figure 1.

All of the following goals involve partnering to coordinate and integrate information collection, management, and dissemination. Such cooperation and collaboration, built purposefully and steadily over time, is essential to their achievement.

Goal 1: Develop a Conceptual Model and the Required Infrastructure (A National Monitoring Framework) that Facilitates the Integration of Information from a Variety of Sources, at Multiple Spatial and Temporal Scales, to Describe and Track the Abundance, Distribution, Productivity, and Health of the Nation's Plants, Animals, and Ecosystems

The Program will work to develop a conceptual model and the required partnerships (a National Monitoring Framework) to facilitate the acquisition, sharing, and integration of scientifically valid status and trends information. In partnership with collaborators, a document will be developed describing the elements that constitute the Framework, the organizational relationships among them, and their contribution to the accomplishment of existing and emerg-



Trumpeter swan with numbered wing tags. This technique allows birds to be monitored remotely without the need for recapture to identify individuals. Photo by Wayne Miller.

ing biological resource monitoring goals. The Framework will undergo periodic review and refinement, and will foster improved programmatic efficiencies and economies of scale through better collaboration than currently exists among public and private organizations.

Goal 2: Develop and Evaluate Inventory and Monitoring Methods, Protocols, Experimental Designs, Analytic Tools, Models, and Technologies to Measure Biological Status and Trends

Achievement of a holistic approach to monitoring the status and trends of biological resources will require that methodologies are current, appropriate to their intended purpose, well documented, scientifically sound, and to the extent possible, compatible among studies. As a part of this effort, the Program will network and cooperate with DOI and other public and private organizations conducting research programs that involve developing biological inventory and monitoring tools and techniques.

Goal 3: Collect, Manage, Archive, and Share Critical, High-Quality Monitoring Data in Cooperation with Partners to Enable a Determination of the Status and Trends of Biological Resources

At the heart of the Program are its existing monitoring activities, and the USGS is committed to continuing the data collection activities that are core to its mission (USGS, 2002). Here again, the Program will coordinate with other agencies and organizations engaged in biological inventory and monitoring to harmonize monitoring efforts and identify gaps where further investments are warranted.

Goal 4: Produce and Provide Analyses and Reports that Synthesize Information on the Status and Trends of Our Nation's Flora, Fauna, and Ecosystems and Respond to the Needs of the Scientific Community, Land and Resource Managers, Policymakers, and the Public

The Program will assess the information collected and produce reports that are relevant to resource management and biological research needs, and provide information and technical support that also meet the needs of DOI and other resource management agencies.

Strategic Plan for the U.S. Geological Survey Status and Trends of Biological Resources Program: 2004–2009

Why Monitor the Status and Trends of Biological Resources?

The Nation's living resources and the habitats on which they depend are undergoing constant change. In the face of influences like climate change, invasive species, and a plethora of human activities, natural resource management and conservation efforts are becoming increasingly challenging and complex.

To protect and conserve the living resources entrusted to their care, land and resource managers must first understand the condition, or *status*, of those resources:

- inventory (what they are),
- abundance (how many there are),
- distribution (where they are located),
- productivity (their capacity to reproduce), and
- health (their well-being, resilience);

and their *trends* (how these variables change over time and space).

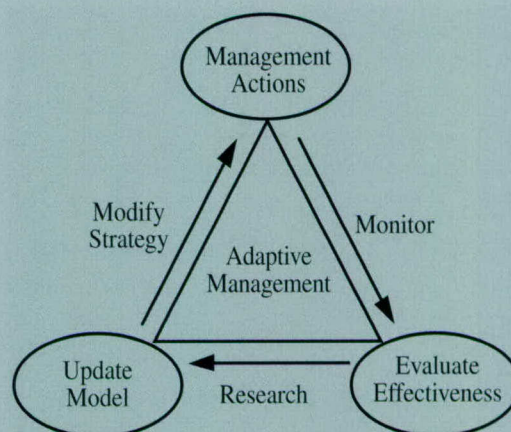
Credible, long-term monitoring is required to satisfy these information needs. In addition, long-term monitoring can be used for

- *detecting changes* that may signal degradation of or improvement in natural systems,
- *identifying new or emerging conditions* that signal the need for management action or further investigative research,
- *providing feedback* critical to evaluating the effectiveness of specific management actions in adaptive management (see inset),
- *validating research results and models*, and
- *promoting increased public understanding* and appreciation of the status and trends of our living resources.

What Is the Organizational Context and Role of the Program?

The U.S. Geological Survey (USGS) Status and Trends of Biological Resources Program recognizes that a wide

variety of public and private organizations are involved in biological or ecological monitoring efforts. Examples include federal entities such as the Departments of the Interior (DOI), Agriculture (USDA), Commerce, Defense, Energy, and Transportation; the Environmental Protection Agency; the National Science Foundation; and the National Aeronautics and Space Administration (NASA)—as well as tribal and state governments, academic and research institutions, and non-governmental organizations (NGOs). This Plan acknowledges the value of these ongoing efforts and promotes collaboration in sharing and integrating data and information generated by the diverse monitoring community. Enhanced cooperation will expand our ability to understand and forecast the condition of our shared biological resources.



Adaptive resource management is a sequential decision-making process for continually improving management policies and practices by learning from the outcomes of previous decisions (Walters, 1986). Long-term monitoring at regular intervals is a critical component of this process to evaluate the resource's response to management action and detect change that may require either adjustments in management actions or further investigative research. In addition, long-term monitoring can span changes driven by natural forces, such as unusual weather patterns, disease events, fire, changes in predator densities, or other factors, so that managers can recognize trends, anticipate outcomes, and adapt management actions to respond to them.

The remainder of this section places the Plan within the context of the DOI and USGS strategic plans and explains how this Plan addresses and responds to their respective monitoring requirements.

Department of the Interior

The mission of the DOI is to protect and manage the Nation's natural resources and cultural heritage; provide scientific and other information about those resources; and honor its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities. To meet its stewardship responsibilities, as conveyed by numerous legislative authorities,¹ the DOI is mandated to estimate the availability and abundance of fish and wildlife resources, determine the distribution and abundance of migratory birds, investigate and report on North American birds, conduct inventories of all public lands and their resources, implement programs for endangered and threatened wildlife and plants, conserve marine mammals, and implement the Convention on Great Lakes Fisheries.

The Department relies upon biological monitoring information to achieve its mission, measure its success in responding to these legislative mandates, and determine its progress toward meeting DOI Resource Protection goals. These include:

- improving the health of watersheds, landscapes, and marine resources that are DOI-managed or influenced in a manner consistent with obligations regarding the allocation and use of water;
- sustaining biological communities on DOI-managed and influenced lands and waters in a manner consistent with obligations regarding the allocation and use of water; and
- protecting cultural and natural heritage resources.

"Now and in the future, rigorous approaches to inventorying and monitoring wildlife resources are needed to provide the information critical to devise, evaluate, and refine management strategies implemented to meet refuge goals and objectives."

U.S. Fish and
Wildlife Service (1999)

To fulfill these goals, the DOI drafted a Strategic Plan (DOI, 2003) that aims to expand its biological information base, improve its data management, enhance technical assistance to resource managers, and improve resource assessment processes in support of these

goals (see box, page 3). More specifically, the DOI Plan identifies performance measures for evaluating its success in

"A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."

U.S. House of Representatives (1999)

achieving desired habitat conditions, restoring burned areas, establishing sustainable populations of targeted species, and evaluating the status and trends of invasive species. The availability of scientifically credible monitoring information is crucial to the ability of DOI to achieve its resource management objectives as demonstrated through established performance measures. Many of the priorities in the Status and Trends Program Strategic Plan derive from and directly support stated DOI information needs. Relationships between DOI goals and Program strategies and desired outcomes are cross-referenced in Table 1.

U.S. Geological Survey

The USGS is the DOI's principal science agency. As such, it is entrusted to provide unbiased, independent data and information on hydrology, geology, geography, and biology.² Specifically, the USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. Included in the USGS mission are requirements to collect natural resource information and conduct systematic analyses and investigations to inform natural resource decision making (USGS, 2002). To achieve its mission, the USGS intends to "continue to improve the quality and usefulness of its long-term data sets," and, where appropriate, work with partners (other federal, state, tribal, and local governments; academic and research institutions; and private organizations) to acquire the necessary data.

²The Organic Act, 43 U.S.C. 31 et seq., 1879; Fish and Wildlife Coordination Act, 1934; Fish and Wildlife Act, 1956; Migratory Bird Treaty Act, 1918; Migratory Bird Conservation Act, 1900; Federal Land Policy and Management Act, 1976; Fish and Wildlife Improvement Act, 1978; Endangered Species Act, 1973; Marine Mammal Protection Act, 1972; Great Lakes Fishery Act, 1956; Nonindigenous Aquatic Nuisance Prevention and Control Act, 1990; Water Resources Development Act, 1990; and other authorizations conveyed to the U.S. Geological Survey.

¹For example, the Antiquities Act, National Park Service Organic Act, Lacey Act, Endangered Species Act, National Wildlife Refuge System Administration Act, and Federal Land Policy and Management Act.

Department of the Interior Strategic Plan Goals and Strategies*

End Outcome Goal 1. Improve the health of watersheds, landscapes, and marine resources that are DOI-managed or influenced in a manner consistent with obligations regarding the allocation and use of water.

Strategy 1-1: Restore and maintain proper function to watersheds and landscapes.

Strategy 1-2: Improve information base, information management, and technical assistance.

End Outcome Goal 2. Sustain biological communities on DOI-managed and influenced lands and waters in a manner consistent with obligations regarding allocation and use of water.

Strategy 2-1: Create habitat conditions for biological communities to flourish.

Strategy 2-2: Manage populations to self-sustaining levels for specific species.

Strategy 2-3: Improve information base, information management, and technical assistance.

End Outcome Goal 3. Protect cultural and natural heritage resources.

Strategy 3-1: Increase knowledge base of cultural and natural heritage resources managed or influenced by DOI.

Strategy 3-2: Manage Special Management Areas for natural heritage resource objectives.

Strategy 3-3: Reduce degradation and protect cultural and natural heritage resources.

Strategy 3-4: Increase partnerships, volunteer opportunities, and stakeholder satisfaction.

*DOI, 2003. DOI and Status and Trends Program goals and strategies coincide and/or support one another. Monitoring underpins the associated measures and outcomes. For a detailed analysis and specific linkages, refer to Table 1, p. 11.

USGS Status and Trends of Biological Resources Program

The Program responds to the monitoring and information needs and requirements of both the DOI and the USGS. It works closely with the resource management community to provide scientifically sound approaches to fulfilling its mission of measuring, predicting, assessing, and reporting the status and trends of our living resources. This Strategic Plan defines the Program goals and outlines a strategy for achieving this mission. The Plan also serves as a tool to guide Program management through periodic Program reviews, annual project reviews, and day-to-day operations.

Program Activities. The Program currently comprises a wide variety of activities. The major components of this approximately \$19 million Program are projects focused on national park monitoring; bird, mammal, and fish monitoring; vegetation mapping; contaminant effects monitoring; development of monitoring standards and protocols; taxonomy, statistics, and museum studies; predictive population modeling; science for decision support systems; adaptive management; and human dimensions and socioeconomic. Program work is enhanced by many additional monitoring projects funded through other internal and external programs and partners.

In FY 2004, there were more than 250 activities funded by the Program. These projects, tasks, and subtasks address



Kristin Simac of the Alaska Science Center's Polar Bear Research Project weighs a radio-collared bear captured on the pack-ice of the Alaskan Beaufort Sea. Photo by Steven Amstrup, USGS.



This endangered California red-legged frog wears a belt-attached transmitter that allows scientists to track individual movements. Photo by Gary M. Fellers, USGS.

status and trends of the full range of biological resources, from wildlife disease pathogens to marine mammals in the Arctic. They also include trends related to socioeconomic factors that influence visitation to public lands. Program activities are diverse given their origins in various DOI bureaus with different missions and priorities. For example, the Program includes (1) status and trends monitoring for endangered species, migratory birds, and marine mammals to help the U.S. Fish and Wildlife Service meet its requirements to manage and protect public trust resources; (2) Great Lakes fish stock assessments to satisfy international agreements and Native American treaty obligations; (3) monitoring of select biota within networks of national parks to help preserve their natural resources and promote biodiversity; and (4) inventory and monitoring of vegetation, invertebrates, and fish populations to assess the impacts of human activities in the Upper Mississippi River for the U.S. Army Corps of Engineers.

Through projects like these and similar efforts (see box, page 5), the Program continues to successfully produce data and information that is highly relevant and timely. A formal review of the Program (USGS, 1999) found that "the Status and Trends Program is a strong and valuable part of the BRD [Biological Resources Discipline] and that...BRD has established strong scientific expertise and leadership in many aspects of inventory and monitoring."

What Are the Needs and Challenges?

Greater Integration of Data and Information at Multiple Scales

Although individual projects of the Program are providing valuable information to the USGS and its partners, they have not yet been integrated into a comprehensive strategy for holistically assessing the abundance, distribution, productivity,

and health of the Nation's plants, animals, and ecosystems. Because they originated in other DOI bureaus with different missions and/or legislative mandates, these monitoring activities are not always comparable or compatible in their design, methodology, or purpose. Further, they are not fully complementary: collectively, they do not represent a complete and comprehensive program of status and trends services and expertise.

The synthesis of data and information derived from biological monitoring projects is a key need. This will produce a more complete, holistic understanding of the status and trends of living systems, spanning multiple spatial and temporal scales. The Program Review (USGS, 1999) stated that "BRD scientists need to view themselves as vital elements of an overall Status and Trends research team that collectively contribute to a grand vision." Hence, the Program needs to move beyond "a loose collection of projects" and integrate information across scales and from multiple sources. However, progress toward integration must be accomplished without compromising the ability to address the data and information needs associated with ongoing, site-specific USGS Status and Trends projects, even as we work to consolidate and align them into a cohesive whole.

The USGS must work with partners and clients to generate relevant biological monitoring data that forms the basis for sound resource management decisions. Only with their participation can a national framework of cooperation and partnership begin to emerge.

"The U.S. government spends hundreds of millions of dollars on the collection of natural resource and environmental data. These activities produce a wide variety of information, designed to be useful in the context of regulatory and management programs. Other entities likewise have used a variety of approaches and chosen different sets of indicators. These activities provide a good basis for further work. Currently the U.S. government does not have a framework to guide federal indicator development or provide a consistent analytic basis for working with international, state or non-governmental indicators endeavors."

CEQ (2002)

A Systems Perspective of Status and Trends

Just as important, the Program needs to approach the status and trends of biological resources from a systems perspective. This means focusing on a holistic view of all species and their habitats placed within a context of the systems (ecosystems) in which they reside. This systems approach to monitoring will require that knowledge be acquired at multiple biological (genetic, species, populations,

Examples of Recent Accomplishments and Ongoing Work of the USGS Status and Trends Program

Breeding Bird Survey (BBS). The BBS is a long-term, continental avian monitoring project designed to track the status and trends of North American bird populations. Each year, during the height of the avian breeding season, participants skilled in avian identification collect bird population data from over 4,100 survey routes located across the continental U.S. and southern Canada. The data provide an index of population abundance that can be used to estimate population trends and relative abundances at various geographic scales. BBS data were instrumental in focusing research and management action on neotropical migrant species in the late 1980s and on grassland species in the mid-1990s. Over 270 scientific publications have drawn heavily from BBS data.

Monitoring Great Lakes Fisheries. Fisheries are a valuable natural resource in the Great Lakes Region, and coordinated research programs are needed to sustain the productivity of these important fish populations. State, tribal, and federal managers across the Great Lakes basin have requested help in providing accurate assessments of fluctuating prey fish populations. For over 30 years, the Great Lakes Science Center has conducted annual bottom trawl surveys in all five Great Lakes that focus on the health of prey fish populations such as alewife, rainbow smelt, bloater, sculpin, and lake herring. This information helps managers with decisions concerning top fish predators (e.g., lake trout, walleye, Pacific salmon, and other sport and commercial fish) that feed on these prey fish. To enhance survey estimates of prey fish populations, the program is expanding to include assessments of pelagic (open-water) fish species using remote sensing technology. Staff are also evaluating the experimental design to provide even better estimates of prey fish abundance and biomass. Since prey fish may be limited by their invertebrate prey as well as by predator populations, scientists also incorporate invertebrate community assessments in survey designs. This important monitoring project enhances our understanding of the processes that shape the fish community and identifies characteristics critical to each species. The resulting long-term data set also can be used for a variety of long-term ecological studies, and enables scientists to address the importance of scale (within lake, between lakes, across basin) in ecological research questions.

Biomonitoring of Environmental Status and Trends (BEST). Since 1995, BEST has assessed fish health and contaminants in the Nation's large rivers. As of late 2004, BEST staff had conducted sampling at over 95 sites within the Columbia, Colorado, Yukon, Rio Grande, and Mississippi River basins. This work documents the impacts of environmental contaminants on fish in large rivers, including reproductive, pathological, and molecular indicators and fish health. BEST also documents and provides training to USGS scientists on several biomarker techniques. For example, monitoring results have identified potential endocrine disruption in large river fish in some sections of the Upper Mississippi River, prompting the USGS and associated state agencies to launch investigations into the causes.

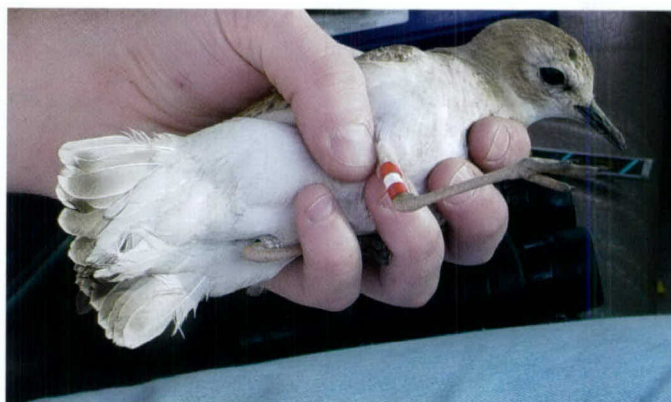
National Park Monitoring. USGS scientists assist national parks with inventory and monitoring protocol development and monitoring-related research needs. Emphasis is on priority issues identified by the National Park Service (NPS) that typically involve and benefit several parks and require multi-year efforts. This work began as the USGS part of the cooperative NPS/USGS Long-Term Ecological Monitoring (LTEM) Program at 11 parks, which were selected by NPS as "prototypes" of specific biomes. Responsibility for a given park is assigned to the closest USGS Science Center with appropriate expertise. During the initial research and design phases of long-term monitoring at that park (usually 3-5 years), the USGS provides funding and full-time staff. After completion of research and protocol designs, monitoring is considered operational, and NPS assumes responsibility.

Status and Trends Assessments. The Status and Trends Program has periodically published comprehensive reports that synthesize our understanding of the Nation's biological and ecological resources (Mac and others, 1998; LaRoe and others, 1995).

etc.), spatial (local, regional, national, global), and temporal (annual, decadal, etc.) scales. A systems approach to monitoring will prove beneficial in the long run by allowing scientists and managers to assess monitoring data in the context of the surrounding ecosystem conditions, with its attendant biotic and abiotic influences, and to recognize patterns not readily apparent when focused only on the smaller scales. Because ecosystem management protects the biodiversity of entire systems, assessing status and trends at the systems level is our long-range target. Although population monitoring is species-specific, there is a relationship between trends in species—particularly indicator or keystone species—and healthy, functioning ecosystems. Thus, increased monitoring of plant and animal populations is essential to understanding ecosystem change and management. Monitoring information must be improved so that it accounts adequately for at least keystone species and representative members of each community and habitat type (Mac and others, 1998).

Human and Fiscal Resources

Coalescing the separate, sometimes narrowly focused and long-standing monitoring activities of the USGS with other DOI bureaus, agencies, and organizations to enable a comprehensive assessment of the status and trends of biological resources is a challenging proposition. This challenge is made even more difficult given that, within this 5-year planning cycle, major funding increases are not anticipated. At the same time, operational costs (salaries, equipment, field work) increase annually. Advancement toward our goals will need to be undertaken with only modest or no additional funding. Yet, one of the priority staffing needs is to build scientific capacity for technical support in designing surveys



This Mountain Plover is wearing colored leg markers that can be viewed from a distance. This facilitates monitoring the bird's movements and other activities without the need for recapture. Photo by Fritz Knopf, USGS.

and monitoring protocols, incorporating appropriate statistical analysis methods, developing population models, and creating methodologies for evaluating the application of information to management. Ultimately, new resources will be required in order for this Plan to succeed and for the Program to reach its full potential.

Another challenge to the Program related to staffing is the perception that monitoring is less scientifically challenging than other scientific research, resource management, or any of the technical roles of the environmental scientist. Because of the repeated nature of monitoring activities, the field is viewed by some as being less creative or ingenious, thereby discouraging some scientists from pursuing monitoring in their professional careers (Mac and others, 1998). This perception may also explain the reluctance of professional supervisors to reward those who do. Once this Plan is implemented—when it begins to provide a structured approach to ensure that biological monitoring yields accessible, integrated, usable information, and its value to federal managers for informing resource management decisions is more broadly recognized—these perceptions should change.

Where Are We Going?

A National Framework for Monitoring Biological Resources

Both the Status and Trends Program Review (USGS, 1999) and the National Research Council (NRC, 1993) recommended that the Program develop a national framework for monitoring biological resources. Development and implementation of this National Monitoring Framework will improve our understanding and enable sound stewardship of the Nation's biological resources and the ecosystems that support them. To this end, the Program will work with willing collabo-



Mist-netting enables capture of bats for health assessment and population monitoring. Photo courtesy of Paul Cryan, USGS.

"The value of statistical indicators for measuring performance, demonstrating accountability and assuring that key policy objectives are being met is well recognized. Good indicators also provide useful information for public discussion about national goals and priorities and the effectiveness of policies and programs. Conflicts over competing uses of natural and environmental resources can often be reduced by providing better information on conditions and trends."

CEQ (2002)

rators to develop a conceptual model and the required partnerships to facilitate the acquisition, sharing, and integration of scientifically valid status and trends information across multiple spatial and temporal scales. In partnership with collaborators, a document will be developed describing the elements

that constitute the Framework (i.e., data generators, data users, information infrastructure, data reporting protocols, etc.), the organizational relationships among them, and their contribution to the accomplishment of existing and emerging biological resource monitoring goals. Specifically, the Framework will (1) increase collaboration in data collection to minimize duplication of effort; (2) better integrate data across taxa and ecological and geographic scales; (3) identify research and information needs; (4) promote new methodologies and analytical techniques; (5) support operational monitoring activities; and (6) enhance our ability to predict, assess, and report the status and trends of our Nation's biological resources.

The Framework will be a "living" construct, neither static nor unchanging, that is periodically reviewed and refined to meet new information needs, respond to organizational changes and challenges, and reflect budgetary realities. Such a Framework will foster improved programmatic efficiencies and economies of scale through better collaboration than currently exists among public and private organizations. This



Individual manatees, like this female and her calf, can be identified by their unique scar patterns, usually a result of collisions with boats. Monitoring populations of this endangered species provides input to decisions concerning management of manatee habitat. Photo by Galen Rathbun, Sirenia Project, USGS.

collaboration, in turn, will render a more comprehensive and efficient information base from which to make planning and operational decisions, thereby strengthening the quality of such decisions and ultimately improving the management of biological resources. In the long term, such an extensive and common information base could be used to anticipate and reduce or mitigate potential conflicts over managing these resources. "A Vision of the Future" (see box, page 8) provides a scenario of how this might work, using one specific example.

How Will We Get There?

Given the many challenges, fully achieving the mission of the Program will take time. Progress will be measured in small, modest gains as scientists and resource managers gradually begin to embrace a new way of doing business and build toward a common, unified approach to monitoring the status and trends of biological resources. Over the next 5 years, progress made in implementing the priority objectives for each Program goal, described below and in Tables 1 and 2, will gauge our success.

All of the following goals and priority objectives involve partnering to coordinate and integrate information collection, management, and dissemination. Such cooperation and collaboration, built purposefully and steadily over time, is essential to goal achievement.

Goal 1: Develop a Conceptual Model and the Required Infrastructure (A National Monitoring Framework) that Facilitates the Integration of Information from a Variety of Sources, at Multiple Spatial and Temporal Scales, to Describe and Track the Abundance, Distribution, Productivity, and Health of the Nation's Plants, Animals, and Ecosystems

Even with partner collaboration, developing and implementing a Framework as described above will require more than the 5 years this Plan covers. However, we can take several significant steps in this time period to move substantially closer to this goal. Our initial objectives are these:

Objective 1A. Identify current inventory and monitoring activities (what, where, why, how, when, by whom, and data accessibility).

Objective 1B. Improve coordination among USGS monitoring activities.

Objective 1C. Improve communication and coordination between the Program, partners, and stakeholders.

Objective 1D. Develop a Framework for monitoring selected biological resources/indicators.

Objective 1A involves working with partner agencies and organizations to inventory and understand the nature of ongo-

A Vision of the Future

A biologist is working to restore 100 acres of dense willow on a major river to benefit nesting neotropical migrant songbirds (yellow warbler, willow flycatcher) and resident moose, river otter, and beaver. To evaluate success of the management strategy, the biologist must implement a vegetation monitoring plan. A wildlife monitoring plan will also be required to document changes in wildlife use and correlate these changes to changes in habitat.

The biologist has access to a variety of technical reports, both in print and on the Web, detailing the status and trends of the species of interest at the national and regional levels. On the Web, she can conduct custom analyses of the status and trends of critical species in the area surrounding the management unit using data from national monitoring surveys.

To design a monitoring program, the biologist accesses the Status and Trends Web site that is supported by and populated with information from all partners (federal, state, tribal, and local governments; academic and research institutions; and private organizations). There she reviews a list of peer-reviewed, scientifically valid methods designed to address specific types of resource questions. The site is continually updated with new applications. In this case the biologist reviews the monitoring issues pertaining to the restoration of riparian habitats along major rivers in the central U.S. Expert systems are available to assist in determining what questions should be addressed, how the sampling design can be applied, what data collection methodologies should be used, and what data analyses are appropriate. A data entry format is provided. She fills it in, and a statistically valid monitoring protocol, responsive to the issues and questions entered, is generated. Comments and suggestions are available from developers and users of the methods as to their strengths and weaknesses. Should additional questions remain, the biologist may use an on-line help link to seek further technical assistance or direct questions to appropriate technical experts. She can then implement the monitoring effort.

In the field, the biologist enters the collected data following the data entry format associated with the protocol, and the information is sent directly to a distributed database maintained by her particular management agency and accessible to others via the National Biological Information Infrastructure (NBII). Expert systems and analytic tools appropriate for use with this protocol are available online to assist with the analysis.

Because common or comparable methods are used, the data may be integrated across multiple spatial and temporal scales. Now the biologist can assess how the observed changes in yellow warblers found on her management unit compare to changes in yellow warblers across their entire range. The broader research community can combine information from this management unit with other data to model and assess biological communities in the river basin, or the flyway. Models developed to assess the system dynamics and variability of the river basin incorporate information on the biological, hydrological, geological, geographical, social, and economic changes occurring within the system. These results are also made available to the biologist to help explain the broader impacts of her unit's specific management actions.



Yellow Warbler. Drawing by Dale Crawford.

ing biological monitoring programs. To accomplish Objective 1B, communication within the USGS will focus on coordinating and integrating information acquired through other Bureau monitoring activities with each other and with USGS research capabilities in order to advance the mission of the Program.

To implement the NRC (1993) recommendations and meet Objective 1C, the USGS will promote and facilitate dialogue among partners to (1) share and increase the collective knowledge concerning the status and trends of biological resources, and (2) work together to develop and advance a Framework to better understand these critical resources. Objective 1D will extend this Plan to include our partners in developing a joint strategy for monitoring critical resources and harmonizing existing efforts.

Goal 2: Develop and Evaluate Inventory and Monitoring Methods, Protocols, Experimental Designs, Analytic Tools, Models, and Technologies to Measure Biological Status and Trends

Achieving a holistic approach to monitoring the status and trends of biological resources will require that methodologies are current, appropriate to their intended purpose, well documented, scientifically sound, and to the extent possible, compatible among studies. The Program Review (USGS, 1999) recommended that the Program should be "the agency leader for the development of basic biological inventory and monitoring protocols...including data quality and analytical standards for monitoring programs."

In addition, the Program should network and cooperate with DOI and other public and private organizations conducting research programs that involve developing biological inventory and monitoring tools and techniques.

Toward these ends, the Program's 5-year priority objectives for meeting this goal are as follows:

Objective 2A. Work with USGS staff, partners, clients, and others to identify, develop, evaluate, and publish methods, analytic tools, and models to measure the status and trends of biological resources.

Objective 2B. Work with USGS staff, partners, clients, and others to coordinate and promote valid, consistent, and



A USGS research vessel operated by the Great Lakes Science Center captures fish in a bottom trawl on Lake Huron. USGS photo.



Technicians sort a bottom trawl sample by size (age) and species as part of the Great Lakes Fish Stock Assessment. USGS photo.

comparable inventory and monitoring designs and methods across USGS regions, among agencies, and between governmental and non-governmental programs.

Objective 2C. In cooperation with partners, periodically review Program monitoring activities to ensure continued relevance and scientific rigor.

Goal 3: Collect, Manage, Archive, and Share Critical, High-Quality Monitoring Data in Cooperation with Partners to Enable a Determination of the Status and Trends of Biological Resources

The existing monitoring activities are at the heart of status and trends work, and the USGS is committed to continuing the data collection activities that are core to its mission (USGS, 2002). This commitment aligns with the Program Review (USGS, 1999) recommendation that the Program continue to implement its operational inventory and monitoring program, but also develop and implement appropriate new



A mountain lion takes a self portrait with a self-triggering camera at a kill site. Non-invasive monitoring methods for these elusive animals are being developed to better understand their movements and behaviors, especially in popular national parks in the West. USGS photo.

projects. Here again, the Program will network with other agencies and organizations engaged in biological inventory and monitoring to become aware of what is already available, and to identify gaps where further investments are warranted. Accordingly, we developed the following objectives:

Objective 3A. Continue, expand, and improve Program monitoring efforts.

Objective 3B. Identify and promote best practices for managing status and trends data and metadata for quality assurance, database design, and data storage and exchange.

Objective 3C. Promote access to inventory and monitoring data and interoperability of databases.

Much of the work to achieve these objectives will be conducted in partnership with other federal, state, tribal, and private agencies and organizations. For example, the National Biological Information Infrastructure (NBII), developed and maintained by the USGS, is actually a consortium of government agencies, academic institutions, non-government organizations, and private industries collaborating to provide increased access to data and information on the Nation's biological resources. The NBII links diverse, high-quality biological databases, information products, and analytical tools maintained by NBII partners and other contributors. Working through programs and partnerships like these to improve biological monitoring and data access and management will allow the Program to deliver higher-quality information that natural resource managers, the research community, and the public can easily retrieve and apply.

Goal 4: Produce and Provide Analyses and Reports that Synthesize Information on the Status and Trends of Our Nation's Flora, Fauna, and Ecosystems and Respond to the Needs of the Scientific Community, Land and Resource Managers, Policymakers, and the Public

Finally, the Program will assess information collected and produce reports that are relevant to resource management and biological research needs. The Program will use information made available from compatible programs in other agencies and will collaborate with these partners, where appropriate, in producing more comprehensive, integrated, and applicable analyses and reports. Hence, these objectives:

Objective 4A. Provide print and Web-accessible reports, syntheses, and other information to advance greater



Tranquilized bighorn sheep get a health check and radio collars for tracking herd movements. USGS photo.

understanding, interpretation, and use of status and trends information.

Objective 4B. Provide information and technical support relevant to DOI and other resource management agency and stakeholder needs.

Our objectives involve continuing and improving the delivery of information products, technical assistance, and other services related to inventory and monitoring. These products and services will focus on answering questions posed by DOI resource managers and the broader resource management and scientific community. Timeliness and ease of access are high priorities for making this information available, and emphasis will be placed on serving data from multiple sources on the Web to reflect information and knowledge on the status and trends of the Nation's biological resources at local, regional, and national scales.

Implementation

Implementation of this Plan (Tables 1 and 2 and Figure 1) will be a significant step toward achieving our Program mission. Progress will be marked by the necessity to revise and update this Plan to reflect new objectives as old ones are met. It will also be manifested in the expansion of committed partners who will work collaboratively to develop a National Monitoring Framework, collecting and sharing data, information, and knowledge on the status and trends of our biological resources.

Table 1. Strategic Plan goals, objectives, strategies, outcomes, and measures for achieving the mission of the Status and Trends of Biological Resources Program, 2004–2009. (Refer to the boxed inset on page 3 for a listing of the DOI Goals and Strategies referenced under the Measure column.)

Goal 1: Develop a conceptual model and the required infrastructure (a National Monitoring Framework) that facilitates the integration of information from a variety of sources, at multiple spatial and temporal scales, to describe and track the abundance, distribution, productivity, and health of the Nation's plants, animals, and ecosystems.			
Objective 1A: Identify current inventory and monitoring activities (what, where, why, how, when, by whom, and data accessibility).			
Strategy	Outcome	Measure	
1A1. Facilitate or host discussions to inventory the current monitoring activities, practices, and needs conducted within USGS and DOI bureaus (within 3 months), other federal agencies (within 1 year), states (within 1 year), and NGOs (within 2 years).	<ul style="list-style-type: none">Ongoing and dynamic compendium of:<ul style="list-style-type: none">major long-term biological monitoring activities,methods and protocols,major data sets of biological status and trends, andmajor data repositories of status and trends information.	<ul style="list-style-type: none">Compendium of monitoring activities is available on the Program Web site (2005).This information is linked to other relevant Web sites (beginning 2005).DOI 1-2; 2-2; 2-3; 3-1; 3-4	
Objective 1B: Improve coordination among USGS monitoring activities.			
Strategy	Outcome	Measure	
1B1. Facilitate communication among Program project chiefs and scientists.	<ul style="list-style-type: none">USGS advisory group established to assess progress in meeting Program goals, identify information gaps, and develop strategies.Annual internal reviews of Program progress and adjustment of priorities.	<ul style="list-style-type: none">Inclusion of Program achievements and priorities in USGS Director's annual guidance (2006).DOI 1-1; 1-2; 2-3	
1B2. Improve communication and collaboration between the Program and other USGS programs.	<ul style="list-style-type: none"><i>Biological Resources Discipline (BRD)</i>: Identification of long-term monitoring needs of other BRD programs, such as the Gap Analysis Program (GAP), Amphibian Research and Monitoring Initiative (ARMI), Invasive Species, Breeding Bird Survey (BBS), etc.<i>Water Resources Discipline</i>: Improved data integration from the National Water-Quality Assessment Program (NAWQA) and National Stream Quality Accounting Network (NASQAN) with Long-Term Resource Monitoring Program (LTRMP) data in the Upper Mississippi River system and the Biomonitoring of Environmental Status and Trends (BEST) Program.<i>Geography Discipline</i>: Expanded interface with the Geography Data (NLCD) set and the BBS data.<i>Geospatial Information Office (GIO)</i>: Engagement of Enterprise Web to ensure Program Web site compliance with all relevant government standards and requirements.	<ul style="list-style-type: none">Annual documentation of monitoring needs across BRD programs, including assessment of gaps and identification of priorities (2006).Report detailing measure of comparability between BEST and NAWQA methodologies (2007).Bird and land-use demonstration pilot study in the Great Plains (2005).Pilot study report published (2006).Fully integrated NLCD and BBS data (2008).Established Program Web site (2005).DOI 1-2; 2-3	

Table 1. Strategic Plan goals, objectives, strategies, outcomes, and measures for achieving the mission of the Status and Trends of Biological Resources Program.—Continued.

Goal 1: Develop a conceptual model and the required infrastructure (a National Monitoring Framework)—Continued		
Objective 1C: Improve communication and coordination between the Program, partners, and stakeholders.		
Strategy	Outcome	Measure
1C1. Facilitate communication and coordination among DOI bureaus regarding measurement of the status and trends of biological resources.	<ul style="list-style-type: none"> Establishment of DOI biological monitoring working group that communicates biological monitoring issues, needs, and activities. Completed inter-bureau biological monitoring initiative. <i>National Park Service (NPS)</i>: Increased USGS participation in the NPS Natural Resource Challenge (USGS National Park Monitoring Project) as well as monitoring programs (e.g., Fire Ecology) in other NPS divisions. <i>U.S. Fish and Wildlife Service (FWS)</i>: Continued work with the FWS to advance all aspects of refuge monitoring. Explored opportunities to assist the FWS in "Fulfilling the Promise." Provided valid and timely information to manage threatened and endangered species and other trust resources. <i>Bureau of Land Management (BLM)</i>: Development and design of system-wide monitoring of rangeland-shrubland systems and monitoring protocols to assess fire rehabilitation efforts. <i>Other DOI Bureaus</i>: Identification of opportunities for shared monitoring strategies by 2008. 	<ul style="list-style-type: none"> Establishment of DOI working group (by 2006). Other examples of bureau coordination and cooperation (2006+). Development of measures for joint funding (2004). Number of jointly funded status and trends activities responsive to the needs of DOI bureaus (2005+; baseline 2004). Opportunities for shared monitoring strategies identified (by 2007). DOI inter-bureau monitoring budget initiative submitted for 2005. Demonstrated use of some comparable protocols among bureaus in major monitoring efforts (baseline 2005). Shared network among bureaus to monitor resources of common concern on Interior lands (2009). DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4
1C2. Facilitate communication and coordination among federal, state, and tribal governments, academic and research institutions, and NGOs concerning measurement of the status and trends of biological resources.	<ul style="list-style-type: none"> Establishment of interagency advisory committee for biological monitoring that incorporates the federal community, states, academic and research institutions, and NGOs to work on an initial draft National Framework. Participated in established committees and/or set up interagency forums for coordination of biological monitoring. <p>Other Federal Agencies</p> <ul style="list-style-type: none"> Established linkage to National Science Foundation Long-Term Ecological Research (LTER) Network and other ecological observation networks. <i>USDA Forest Service</i>: Coordinated with Forest Inventory and Analysis (FIA), Natural Resources Conservation Service (NRCS), Natural Resource Inventory, and Forest Health Monitoring (FHM) programs in conducting USGS surveys, including the Breeding Bird Survey and others. <i>Army Corps of Engineers</i>: Incorporated systems approach within inventory and monitoring efforts such as the Missouri River (in partnership with the Missouri River Basin Association). Explored and identified potential linkages to parks and refuges. 	<ul style="list-style-type: none"> Development of a national plan for monitoring a mutually identified biological resource (more specific measures of success to be determined by the committee; 2007). Specific examples of coordination and cooperation (beginning 2005). Specific examples of jointly funded activities between USGS and partners and stakeholders (beginning 2005). DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4

Table 1. Strategic Plan goals, objectives, strategies, outcomes, and measures for achieving the mission of the Status and Trends of Biological Resources Program.—Continued.

Goal 1: Develop a conceptual model and the required infrastructure (a National Monitoring Framework)—Continued		
Objective 1C—Continued		
Strategy	Outcome	Measure
1C2. Continued	<p>States</p> <ul style="list-style-type: none"> • Engaged the International Association of Fish and Wildlife Agencies (IAFWA) regarding State Comprehensive Wildlife Conservation Plans. • Collaboration with states in addressing their resource monitoring needs. • Coordinated with states and other organizations on the North American Bird Conservation Initiative (NABCI). • Coordinated with state Natural Heritage Programs and, where they exist, research divisions of state fish and wildlife agencies. <p>Other Governments</p> <ul style="list-style-type: none"> • Coordinated with state, tribal, and other public and private agencies on existing or planned monitoring efforts. • Cooperated with tribal and international governmental organizations to meet treaty and trust obligations. <p>NGOs and Multi-Stakeholder Groups</p> <ul style="list-style-type: none"> • Communicated and promoted the linkage of Program efforts to other ongoing monitoring efforts. • Participated in professional societies to promote the development and review of protocols and the concept of a national framework; • Partnered with NatureServe in the acquisition and delivery of biodiversity information. • Participated in Roundtable for Sustainable Forests and Sustainable Rangeland. <p>Public</p> <ul style="list-style-type: none"> • Explored ways to effectively utilize an informed public in the collection of information that contributes to our scientific understanding of the status and trends of biological resources. 	

Table 1. Strategic Plan goals, objectives, strategies, outcomes, and measures for achieving the mission of the Status and Trends of Biological Resources Program.—Continued.

Goal 1: Develop a conceptual model and the required infrastructure (a National Monitoring Framework)—Continued			
Objective 1D: Develop a framework for monitoring selected biological resources/indicators.			
Strategy	Outcome	Measure	
1D1. Develop, with collaborators, a conceptual model for monitoring selected biological resources/indicators.	<ul style="list-style-type: none">Monitoring objectives and criteria identified among partners.	<ul style="list-style-type: none">Conceptual model published on the Web with concurrence of partners (2007).DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4	
1D2. Development of a Framework document for monitoring selected biological resources/indicator(s).	<ul style="list-style-type: none">Consensus among partners on Framework and its implementation.	<ul style="list-style-type: none">Framework document published on the web with concurrence of partners (2008).DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4	
Goal 2: Develop and evaluate inventory and monitoring methods, protocols, experimental designs, analytic tools, models, and technologies to measure biological status and trends.			
Objective 2A: Work with USGS staff, partners, clients, and others to identify, develop, evaluate, and publish methods, protocols, analytic tools, and models to measure the status and trends of biological resources.			
Strategy	Outcome	Measure	
2A1. Document and develop statistically valid, efficient, and feasible protocols that are relevant to the needs of resource managers for monitoring the abundance, distribution, productivity, and health of the Nation's plants, animals, and ecosystems.	<ul style="list-style-type: none">Developed protocols with clearly defined goals and measurable management objectives; involved all relevant disciplines including resource managers, taxa biologists, and statisticians; developed detailed methods, standard operating procedures, and rationale for survey design, training, and data collection, management, and quality control; submitted metadata to clearinghouse; developed analysis and reporting procedures.Developed protocols applicable at multiple spatial and temporal scales.Ensured that status and trends data are useful at multiple scales (e.g., FWS Refuge Conservation and Research Program).	<ul style="list-style-type: none">Peer-reviewed biological monitoring protocols accessible via print or Web (baseline 2005).Peer-reviewed biological monitoring protocols used by land and resource management agencies (2006).Program data are useful at multiple scales (e.g., FWS Refuge Conservation Research Program; 2007).DOI 1-2; 2-3	

Table 1. Strategic Plan goals, objectives, strategies, outcomes, and measures for achieving the mission of the Status and Trends of Biological Resources Program.—Continued.

Goal 2: Develop and evaluate inventory and monitoring methods—Continued			
Objective 2A—Continued			
Strategy	Outcome	Measure	
2A2. Ensure that measurements have sufficient accuracy for their intended purpose, considering the variances, biases, and costs.	<ul style="list-style-type: none">• Considered detectability in all estimates of abundance to ensure that the bias is small relative to the anticipated effects.• Sample sizes and designs provide sufficient confidence and power to characterize or detect important effects.• Statistically valid and efficient probability sampling designs provide reliable estimates and minimize costs, considering the relative effectiveness of alternative methods and their associated variance components and costs.• Demonstrated the relationship between the measured quantity and the parameter of interest when an index or surrogate is used.	<ul style="list-style-type: none">• Detectability measures have been assessed, and if appropriate, are routinely incorporated into the BBS (2008), ARMI (2005), and Great Lakes deep-water fish stock assessments (2007).• DOI 1-2; 2-3	
2A3. Develop and make available analysis and synthesis tools to allow use of status and trends data and information.	<ul style="list-style-type: none">• Tools are available on the Internet (i.e., the Program Web site).	<ul style="list-style-type: none">• Verified the extent to which these tools are used for analysis and interpretation of Program data (2005).• DOI 1-2; 2-3	
Objective 2B: Work with USGS staff, partners, clients, and others to coordinate and promote valid, consistent, and comparable inventory and monitoring designs and methods across USGS regions, among agencies, and between governmental and non-governmental programs.			
Strategy	Outcome	Measure	
2B1. Use discussions and engage groups referenced in Objectives 1C1, 1C2, and 2A1 to develop, share, and utilize standards and promote comparability among major monitoring efforts.	<ul style="list-style-type: none">• Developed best practices, protocols, and methods for taxa and habitats.• Improved comparability among a limited suite of major protocols.• Protocols are available on the Internet.	<ul style="list-style-type: none">• Information available in reports and on the Internet (2007).• Number of comparable designs and methods used (2009).• DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4	
2B2. Identify opportunities (e.g., NBII nodes) and/or existing regional monitoring efforts (e.g., Chesapeake Bay Watershed, etc.) to serve as a pilot study for a pilot network.	<ul style="list-style-type: none">• At least one pilot coordination effort initiated by 2006.• Consistent and comparable inventory and monitoring designs and methods are employed within a defined network of monitoring sites.	<ul style="list-style-type: none">• Documented examples of challenges/benefits to adopting monitoring standards (2008).• Shared information between cooperating resource management agencies (2006).• DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4	

Table 1. Strategic Plan goals, objectives, strategies, outcomes, and measures for achieving the mission of the Status and Trends of Biological Resources Program.—Continued.

Goal 2: Develop and evaluate inventory and monitoring methods—Continued		
Objective 2C: In cooperation with partners, periodically review Program monitoring activities to ensure continued relevance and scientific rigor.		
Strategy	Outcome	Measure
2C1. Conduct scientific reviews of all major long-term monitoring projects as part of established 5-year Program Reviews.	<ul style="list-style-type: none"> • A schedule of reviews for 2004-2009. • Assembled committee of internal and external partners to review the Program's projects. 	<ul style="list-style-type: none"> • Completed reviews of Program projects incorporated into Five-Year Program Review report (late 2006). • Reviews available; recommendations for improvement incorporated into the relevant monitoring projects (2007). • DOI 1-2; 2-3
Goal 3: Collect, manage, archive, and share critical, high-quality monitoring data in cooperation with partners to enable a determination of the status and trends of biological resources.		
Objective 3A: Continue, expand, and improve Program monitoring efforts.		
Strategy	Outcome	Measure
3A1. Continue major long-term monitoring projects.	<ul style="list-style-type: none"> • Current efforts were sustained with appropriate resources. 	<ul style="list-style-type: none"> • Regular continued availability of reports, peer-reviewed publications, and accessible, geo-referenced databases via the Program Web site (2005). • DOI 1-2; 2-3
3A2. Expand the scope of existing surveys.	<ul style="list-style-type: none"> • More species included in long-term monitoring. • Expanded geographic scope of biological monitoring (e.g., BBL has been expanded into Mexico). • Expanded suite of chemical contaminants monitored in assessing effects on biological resources. 	<ul style="list-style-type: none"> • Documentation of expanded surveys in reports, peer-reviewed publications, and accessible, geo-referenced databases (baseline 2004). • DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4
Objective 3B: Identify and promote best practices for managing status and trends data and metadata for quality assurance, database design, and data storage and exchange.		
Strategy	Outcome	Measure
3B1. Identify and share best practices and standards for biological inventory and monitoring data.	<ul style="list-style-type: none"> • Agreement among agency inventory and monitoring database managers on selected best status and trends data management practices and standards, and approved by NBII, Federal Geographic Data Committee, and others. 	<ul style="list-style-type: none"> • Documented and approved data management and integration standards for biological inventory and monitoring data (2008). • DOI 1-2; 2-3
3B2. Upgrade data collection, management, and analytical capabilities.	<ul style="list-style-type: none"> • Upgraded databases to ensure protection of and access to data and analysis tools, and to facilitate interoperability. 	<ul style="list-style-type: none"> • Documentation of upgrades in annual reports (2008). • DOI 1-2; 2-3

Table 1. Strategic Plan goals, objectives, strategies, outcomes, and measures for achieving the mission of the Status and Trends of Biological Resources Program.—Continued.

Goal 3: Collect, manage, archive, and share critical, high-quality monitoring data—Continued			
Objective 3B—Continued			
Strategy	Outcome	Measure	
3B3. Ensure complete and accurate metadata records.	<ul style="list-style-type: none">Documented status and trends data and information, in complete and accurate metadata records, are available through the NBII Metadata Clearinghouse.	<ul style="list-style-type: none">Completed metadata for all new and existing long-term monitoring projects funded through this Program are accepted by NBII Metadata Clearinghouse by 2006.DOI 1-2; 2-3	
Objective 3C: Promote access to inventory and monitoring data and interoperability of databases.			
Strategy	Outcome	Measure	
3C1. Establish, maintain, and accelerate the sharing, standardization, completeness, and accessibility of existing data (e.g., via NBII).	<ul style="list-style-type: none">Long-term monitoring data and information are available on NBII.Online reporting of status and trends of biological resources for the Nation.Legacy data has been identified, recovered, and reviewed for application to status and trends assessments.	<ul style="list-style-type: none">Measures of status and trends data accessibility and use (baseline 2005).DOI 1-2; 2-3; 3-4	
Goal 4: Produce and provide analyses and reports that synthesize information on the status and trends of our Nation's flora, fauna, and ecosystems and respond to the needs of the scientific community, land and resource managers, policymakers, and the public.			
Objective 4A: Provide print and Web-accessible reports, syntheses, and other information to advance greater understanding, interpretation, and use of status and trends information.			
Strategy	Outcome	Measure	
4A1. Develop Program Web site.	<ul style="list-style-type: none">Program Web site includes:<ul style="list-style-type: none">Program information (projects, funding, activities, accomplishments),current inventory and monitoring activities and resources, andaccepted inventory and monitoring protocols and standards.	<ul style="list-style-type: none">Program Web site is available and used by scientists, resource managers, and the public, as indicated through Web analytics (2005).Web site reflects expectations of the user community as assessed through surveys and other feedback (2006).DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4	
4A2. Continue publication of status and trends results and findings.	<ul style="list-style-type: none">Peer-reviewed publications, technical and non-technical fact sheets, Web pages, brochures, and briefings.	<ul style="list-style-type: none">Number of Program products and accomplishments reported in BASIS+ (2005).Program Web site and publications contain the latest available accounts of the status and trends of the Nation's living systems (2006).DOI 1-2; 2-3	

Table 1. Strategic Plan goals, objectives, strategies, outcomes, and measures for achieving the mission of the Status and Trends of Biological Resources Program.—Continued.

Goal 4: Produce and provide analyses and reports that synthesize information—Continued			
Objective 4A—Continued			
Strategy	Outcome	Measure	
4A3. Periodically publish the Program synthesis report, <i>Status and Trends of the Nation's Biological Resources</i> .	<ul style="list-style-type: none">Report represents a dynamic, online account of the status and trends of the Nation's plants, animals, and ecosystems reported from representative groups.	<ul style="list-style-type: none"><i>Status and Trends of the Nation's Biological Resources</i> is published (2008).DOI 1-1; 1-2; 2-1; 2-2; 2-3; 3-1; 3-2; 3-3; 3-4	
Objective 4B: Provide information and technical support relevant to DOI and other resource management agency and stakeholder needs.			
Strategy	Outcome	Measure	
4B1. Develop information on inventory and monitoring standards and protocols for field biologists and resource managers.	<ul style="list-style-type: none">Inventory and monitoring manuals for the user community.	<ul style="list-style-type: none">Manuals and guidance documents used by land and resource managers have been broadly disseminated (document manuals and guidance documents 2006).DOI 1-2; 2-3	
4B2. Provide training, workshops, and one-on-one assistance to land and resource managers.	<ul style="list-style-type: none">Information disseminated to a broader community.	<ul style="list-style-type: none">Number of courses, workshops, and technical assistance provided and degree of success as determined by feedback from training recipients (baseline 2006).DOI 1-2; 2-3	

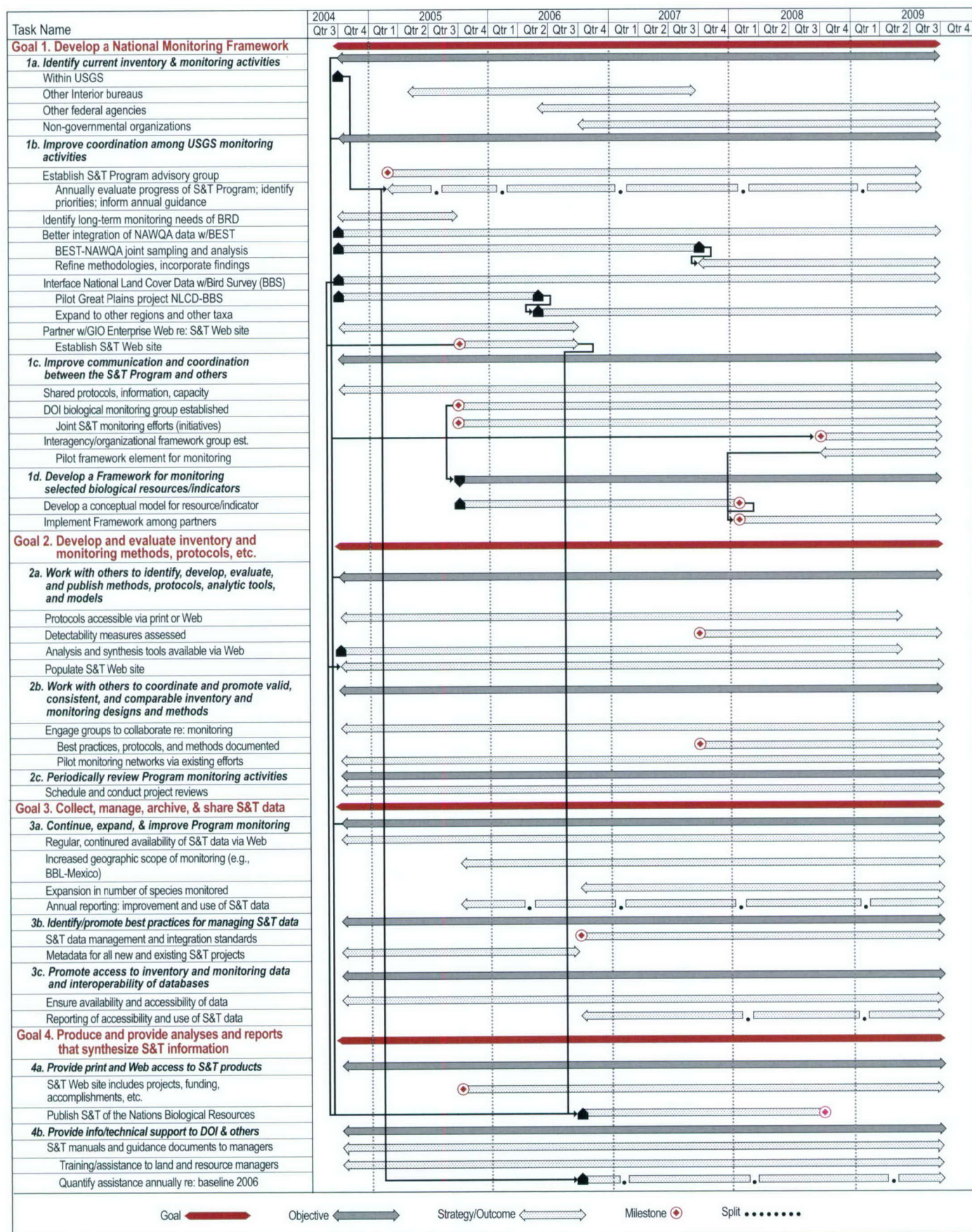


Figure 1. Summary and timeline of Status and Trends Program goals, objectives, outcomes, measures, and milestones: 2004–2009.

Table 2. Recommended directions by taxa and theme for advancing Program goals.

Taxon/theme	Recommendations
Birds	Incorporate measurement detection probability into survey design of the BBS; ensure adequate bird band supply for the BBL; increase the number of species monitored by long-term surveys; expand the geographic scope of existing surveys; improve the bird population database infrastructure and data delivery; contribute to the bird status and trends objectives of NABCI.
Fish	Develop a strategic plan for fish monitoring in the Great Lakes, Mississippi River systems, Grand Canyon, and Colorado River; incorporate fish monitoring programs into databases for exotic species; develop methods to provide easy access to fish monitoring data of the Great Lakes and Colorado River; assess feasibility of hydroacoustic monitoring methods in the Great Lakes; implement a monitoring system for the Missouri River.
Mammals	Compile, evaluate, and summarize activities to measure and assess the status and trends of mammalian species on a state-by-state basis; evaluate current activities for managerial relevance (e.g., chronic wasting disease) and statistical rigor; analyze these activities for estimation of status and trends; report to states the findings of the efforts leading to improved methods, collaboration, and partnerships.
Invertebrates	Explore use of taxonomic services through the USGS Water Quality Laboratory to identify aquatic invertebrates, and through the Smithsonian, academic institutions, and USGS scientists to identify terrestrial invertebrates; develop standard sampling strategies for aquatic and terrestrial invertebrates; investigate the utility of using NAWQA invertebrate data to assess status and trends of aquatic invertebrates; develop a strategy to assess status and trends in terrestrial invertebrates; work toward a common protocol and shared Program information base with emphasis on pollinators, soil food-web organisms, and freshwater mussels.
Amphibians and reptiles	Enhance the capabilities of existing amphibian monitoring efforts; better utilize and coordinate the complementary approaches of the North American Amphibian Monitoring Program and ARMI to yield improved estimates of the status and trends of amphibians; explore the establishment of a framework for monitoring status and trends of reptiles.
Plants, lichens, and mosses	Work toward development and evaluation of regional protocols for inventory and assessment of plant, lichen, and moss status and trends; develop and evaluate national protocols for their status on U.S. grasslands, woodlands, forests, and rangelands (e.g., Forest and Rangeland Roundtables).
Imperiled species	Maintain capability for determining status and for monitoring and predicting trends for federally listed species, candidate species, and species of concern. Increase accessibility to imperiled species data from multiple sources.
Ecosystems	Tie species status and trends to ecological systems. Map ecological systems and habitat quality over time, corresponding to species population status and trends (which species are declining, stable, improving per habitat type, over time). Work toward using knowledge base (species-system status and trends) to begin identifying key sets of indicators of ecosystem status and trends; strive to formalize linkages to other ecosystem-related efforts such as the LTER Network and the National Science Foundation's National Ecosystem Observation Network (NEON).
Genetics	Develop guidance to incorporate genetic sampling as a standard monitoring tool; develop cost-effective contaminant screening tools; develop an inventory/database of molecular markers for trust species; incorporate genetic information within Program reporting vehicles.
Microbes	Host workshop to identify current and future approaches (e.g., genetic and molecular techniques) to inventory and monitor microbial species/groups and their function in natural systems.

Table 2. Recommended directions by taxa and theme for advancing Program goals.—Continued.

Taxon/theme	Recommendations
Contaminants	Complete plans to increase the efficiency (leverage with other efforts) and spatial extent of the BEST Program efforts to monitor and assess contaminant effects on fish in large U.S. rivers; improve capability to integrate findings of BEST and NAWQA; establish, maintain, and accelerate the sharing, standardization, completeness, and accessibility of existing data on the distribution, concentrations, and effects of environmental contaminants by maintaining and enhancing online databases; provide training to DOI bureaus on collection, use, and interpretation of biocontaminants.
Invasives	Coordinate and promote consistent and comparable inventory and monitoring designs and methods for invasives (e.g., early detection in ballast water); establish, maintain, and accelerate the sharing, standardization, completeness, and accessibility of existing data on invasive species via the NBII Invasive Species Information Node; use this Node as a vehicle to promote a status and trends monitoring network for invasive species; provide technical assistance to government and NGOs on all aspects of the inventory and monitoring of invasive species.
Human dimensions	Provide ongoing assessments of the social, economic, and institutional implications of resource use; monitor changing human development patterns; develop techniques to assess the economic and social effects of environmental trends and conditions; design research to guide use of socioeconomic data in decision making and better management of natural resource conflicts.
Taxonomy and systematics	Provide taxonomic and systematic research and identification services on North American biota to support status and trends activities; provide a credible, automated taxonomic reference of North American biota; work to develop the interface between taxonomic/genomic data.
Remote sensing	Promote dialogue among the internal/external science community to enhance and improve methodologies for use of remote sensing to address Program goals; work toward development of standards for evaluation and consistency of remote sensing data and methodologies.
Standards and protocols	Ensure statistical and managerial input into standards and protocols; peer review and publish (Web or print) protocols; enhance multidisciplinary nature of protocols that are guided by conceptual models of the system/questions; strengthen the connection between survey goals and protocols; ensure that protocols relate to all aspects of a survey, including analysis and dispersion of information; incorporate measures of comparability among methodologies; incorporate measures of detectability and confidence in survey/monitoring designs.
Statistical tools and modeling	Ensure that objectives for each Program activity are measurable and of sufficient clarity that a reasonable observer may determine if an objective is achieved; demonstrate the feasibility of each Program activity to produce valid and reliable results within existing resources; develop methodologies to use status and trends data collected at variable scales to enable valid and reliable status and trends determinations of species, genera, and systems; through analysis and modeling, recommend valid and reliable inferences to identify species, genera, or functional groups as indicators of ecosystems; enhance the multidisciplinary nature of models.
Data and information management and reporting	Ensure the availability of status and trends methodologies, analytic tools, data, information, and products using the infrastructure of the NBII; identify needed priorities for data and information to be made interoperable with those of other USGS Disciplines and organizations; identify work needed to develop and implement a dynamic, online account of the status and trends of the Nation's plants, animals, and ecosystems.

List of Abbreviations

ARMI	Amphibian Research and Monitoring Initiative
BBL	Bird Banding Laboratory
BBS	Breeding Bird Survey
BEST	Biomonitoring of Environmental Status and Trends
BLM	Bureau of Land Management
BRD	Biological Resources Discipline
DOI	Department of the Interior
EROS	Earth Resources Observation Systems
FHM	Forest Health Monitoring
FIA	Forest Inventory and Analysis
FWS	U.S. Fish and Wildlife Service
GAP	Gap Analysis Program
GIO	Geographic Information Office
IAFWA	International Association of Fish and Wildlife Agencies
LTEM	Long-Term Ecological Monitoring
LTER	Long Term Ecological Research Network
LTRMP	Long Term Resource Monitoring Program
NAAMP	North American Amphibian Monitoring Program
NABCI	North American Bird Conservation Initiative
NASQAN	National Stream Quality Accounting Network
NAWQA	National Water-Quality Assessment Program
NBII	National Biological Information Infrastructure
NEON	National Ecological Observatory Network
NGO	Non-governmental organization
NLCD	National Land Cover Data
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
OMB	Office of Management and Budget
PART	Program Assessment Rating Tool
S&T	Status and Trends
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

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